CQ REVIEWS:

The Ten-Tec Model 253 Automatic Antenna Tuner

BY LEW McCOY*, W1ICP

Over the years I have written many articles dealing with antenna tuners and Transmatches, so I guess I am as familiar with the subject as can be. In fact, I was instrumental in coining the word "Transmatch" back in the 1950s. Throughout that time period there had been several attempts in the amateur industry to come up with a Transmatch that was completely automatic in that it would take an unknown antenna system load and match it to 50 ohms—the desired design impedance of nearly all modern equipment. Note I say amateur industry, because there have been some commercial and military units. Even so, these devices have been limited in their ranges. The reason for that was there was usually no need for a really wide-ranging matching system in the commercial field. Antennas were of a specific type, and the feed impedance was in a limited range.

However, in amateur radio, particularly with random-length dipoles and open-wire-type feeds, the load excursions can be tremendous, and automatically tuned antenna tuners usually cannot match such loads simply because we must cover so many bands and frequencies. There have been some types designed in the past to automatically match *any* load, but none have really been completely effective unless a particular antenna is used.

The Tec-Tec Model 253, however, is a very pleasant departure from the past. It *will* match literally any load with an SWR of less than 10 to 1. I have tested this unit extensively, and believe me, I tried some really *exotic* loads, such as an 8 foot (10 meter) whip on 80 meters. Here we are looking at a radiation resistance that is a fraction of an ohm, but Ten-Tec handled it. For kicks I had some high-value wire-wound resistors which would produce a 10 to 1 load. You will have to admit that is fairly high. No problem. The 253 circuits whirred, and suddenly there was a matched condition of less than 1.3 to 1. A match of 1.3 to 1 or better is the matching condition for which the unit shoots.

Probably the best way to describe what happens is to quote from the very excellent instruction manual—the section on the theory of operation. I might add that I agree almost 100 percent with the theory, and if anyone questions my use of the Ultimate circuit of the T, it is simply because such are *manually* tuned devices (plus they will match more than a 10 to 1 mismatch). Following are the book's words. I have footnoted those areas of discussion where there should be more explanation.

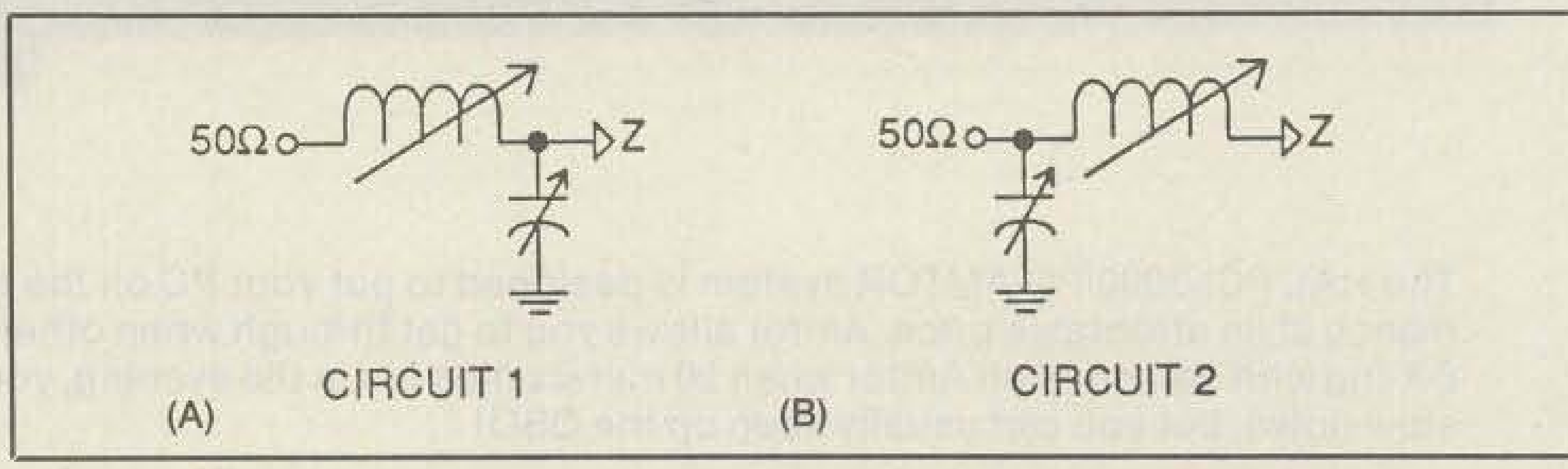


Fig. 1– At (A) we have configuration 1 and at (B) configuration 2.

Theory of Operation

The problems of matching a 50 ohm transmitter to an unknown antenna impedance can be solved by different circuit configurations. For the Model 253 Automatic Antenna Coupler, a reversible low-pass L-network (see fig. 1 at [A] and [B]) was chosen over a PI or TEE configuration for the following reasons.

1. After tuning, the bandwidth of the

This is the Model 253 completely automatic antenna tuner rated at 2 KW.

*Technical Editor, CQ, 200 Idaho St., Silver City, NM 88061

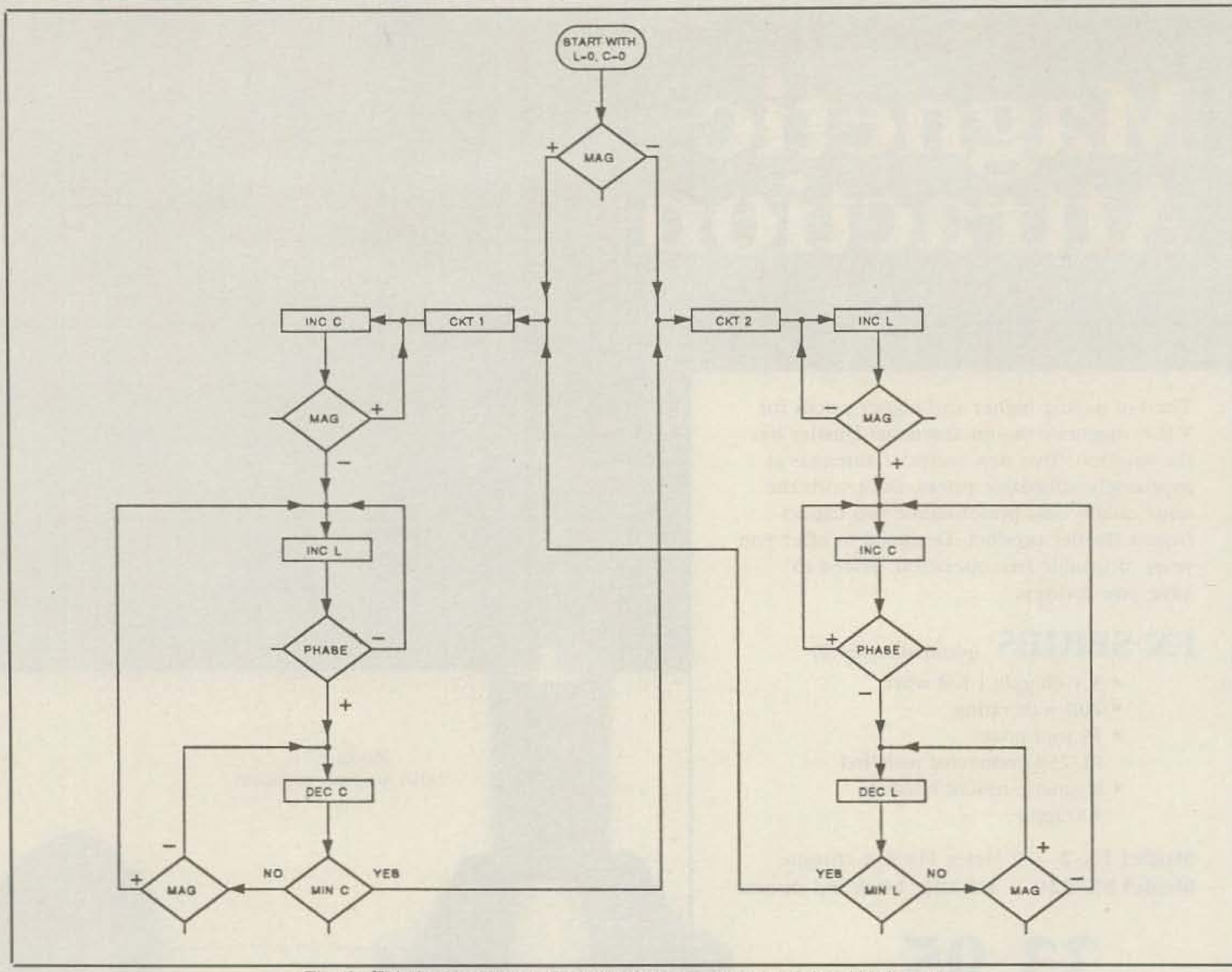


Fig. 2– This is the automatic tuner flow chart as explained in the text.

match is wider than can be obtained with a single section PI or TEE network and, for a given inductor Q,[1] the loss is lower. This means that after tuning on a given frequency, larger excursions from that frequency can be tolerated without having to retune. Also, lower inductor loss translates to higher coupler efficiency.

2. The L-network offers the lowest component count possible for a general impedance network.[2] This is especially important in an automatic tuner, since the component values must be variable. Each additional network component requires another motor or relay bank to adjust the value.

3. There are no "internal" nodes or loops in an L-network. This means that the voltages and currents inside the coupler are never higher than the input and output voltages and currents.[3]

4. For an L-network, there is only *one* set of component values which provides an impedance match for any given load. Therefore, when a match is found, it is automatically the "best match" (lowest loss and widest bandwidth).[4] PI and TEE networks can produce a match at several different settings, each with a different circuit Q.[5]

5. The low-pass configuration of the L-network provides two additional poles of harmonic filtering. This can help[6] reduce TVI caused by harmonic and high-frequency spurious outputs of transmitters. Many antenna tuners use a *high-pass* circuit configuration. Although a properly operating high-pass tuner will not *cause* TVI, it will not help either.[7]

6. With only two variable circuit elements (and a reversing switch) the automatic tuning procedure or "algorithm" is much simplified. (This is the end of my extraction from the manual.)

So what we have in the Model 253 is a variable motor-driven inductor and switched capacitor bank. The object is to take an unknown antenna load, and this can be a very small radiation resistance or a very large radiation resistance, plus an unknown amount of reactance and convert these or this unknown load to 50 ohms. The entire algorithm for determining the correct values of L and C to find such a match is much beyond the scope of this review. However, fig. 2 is a flow chart that provides a simplified version of what happens. The timing and control functions are not pointed out, but the flow chart shows the basic routine or path followed.

Keep in mind that there are two circuit configurations with our PI—fig. 1 at (A) or (B). We start trying to match with fig. 1(A). The inductor rotates, with the algorithm searching for a match, meanwhile switching capacitors out of the circuit. If the capacitor value reaches zero, the algorithm tells the unit to switch to configuration (B) and then proceeds until it reaches a match of 1.3 to 1 or less. When that point is reached, the microprocessor stores the setting information in its memory so that it can instantly be called up when changing bands. In other words, set it once and forget it.

I've sort of done this review backwards in telling you how it worked rather than what it will do, so let's cover that. The 253 is an antenna coupler that will take an unknown load of less than 10 to 1 and convert it to less than 1.3 to match. (Although my own experience showed it did match many loads greater than 10 to 1. I appreciate the fact that the designers are being conservative.) The antennas can be either coax fed or have balanced feed lines. There are four coax-fed antenna inputs (or three) if a balanced line is brought in.

The tuning unit is rated at 2 KW maximum, and I thoroughly tested at the legal limit of 1500 watts. Frequency range is from 1.8 to 30 MHz (continuous, so it covers MARS frequencies). DC power requirements are 12 to 14 volts at 2 amperes (not furnished). The automatic tuning time is approximately 5 seconds typical. From a cold start, say from 10 meters to a match on 160, could take 30 seconds.

In the memory tuning, the tuner automatically returns to settings last being used for each antenna switch position. Separate settings can be stored for each band if a remote band connector is used. Retuning (auto or manual) updates memory.

There are four antenna positions as mentioned earlier and seven band positions, giving a total of 28 memory positions. In other words, once you let the tuner adjust itself for 80 meters, for example, and then switch to another band and let it adjust, these settings are entered into memory. When you switch back to 80, the tuner turns on and in just a few seconds shuts itself off—completely matched. At the very least, it is an ingenious device.

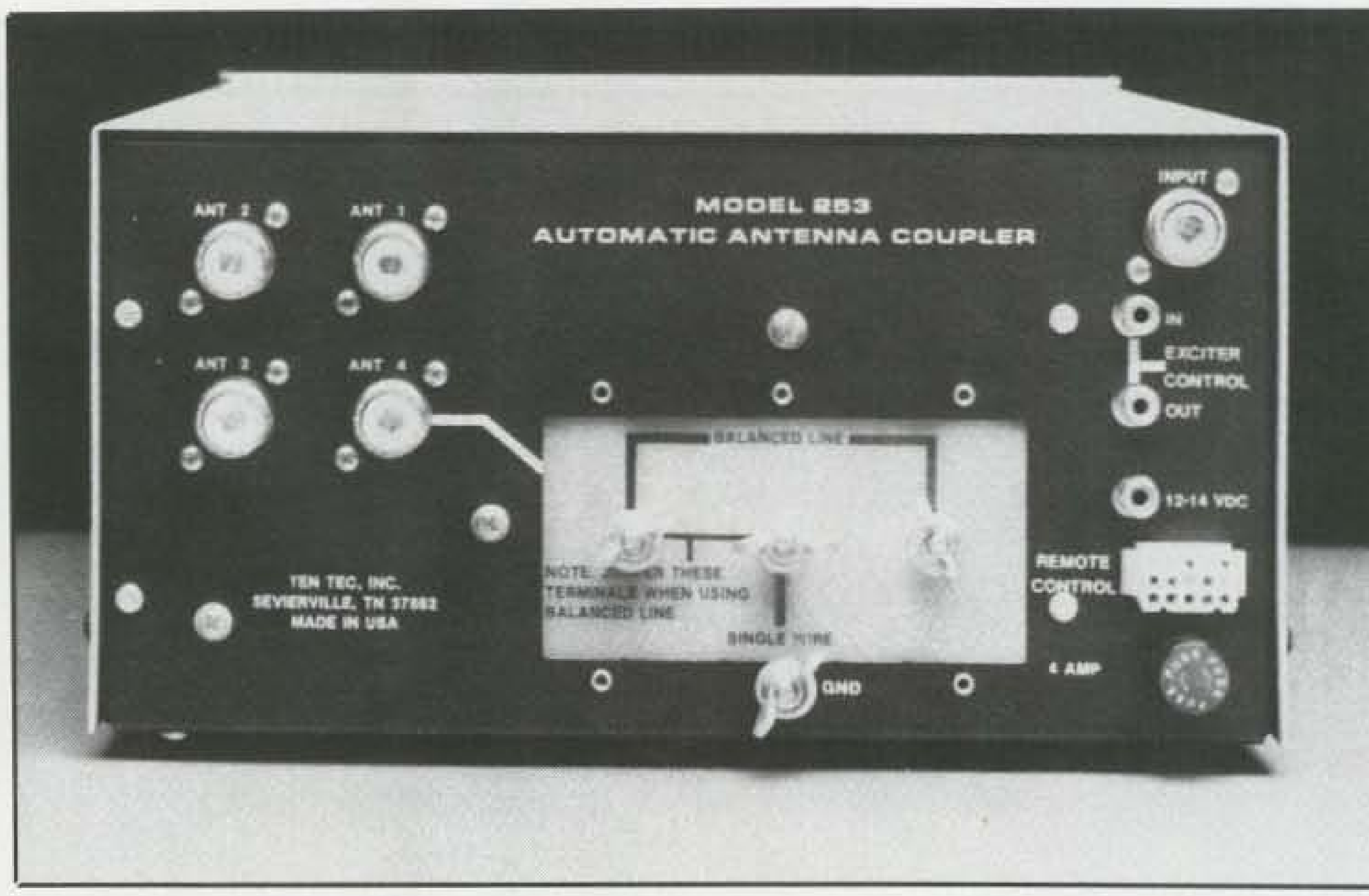
For the technically minded, here are the matching figures: At least 10 to 1 SWR matching, any phase angle, 1.8 to 30 MHz. Thirteen-hundred (1300) ohms maximum parallel equivalent resistance at 1500 watts output (2 KV peak at better than 26 to 1 SWR). Five-thousand ohms maximum parallel equivalent resistance across balanced line at 1500 watts output.

There is over-voltage protection built in. An **ARCING** indicator illuminates when the RF voltage exceeds 2 KV. The tuner is reset to bypass mode if **ARCING** or **OVER** indication remains on for more than 1 second. A hot switching system protection is provided by an internal relay interlock system.

Internal power bridge and circuitry are built in, of course. The front-panel meter has four switch positions—**SWR, SET, 200 WATT,** and **2000 WATT.** The unit is 5½ inches high, 14 inches deep, and 10½ inches wide.

It should be apparent from the foregoing that I was extremely impressed by the automatic tuner. Ten-Tec has apparently taken all conditions into consideration and more than met them. While I didn't mention it before, if you have band information output provided by your transceiver, this output can be fed to the tuner so that when you change bands, the tuner is automatically set up with the transceiver. The neophyte should not confuse this tuner with some of the other "built in" transceiver antenna tuners. This unit will match almost *any* load, while the others can be very limited or require specific antennas.

The current list price of the Model 253 is $1150.00. The unit is manufactured by Ten-Tec, Inc., Highway 411 East, Sevierville, TN 37862.



Back view of the tuner. At the upper left are the four antenna outputs. The lower center panel is for a balanced feed connection. Remote control is at the right.

Footnotes

The following are author's notes and comments on the material quoted from the unit's instruction manual.

1. The only problem you should be aware of is that in a *manually* tuned setup there is always the possibility of getting extremely high Qs with corresponding high RF voltages, but that is not a problem in this circuit.

2. I heartily agree. The fewer the variable components, the simpler and more trouble-free the circuit is.

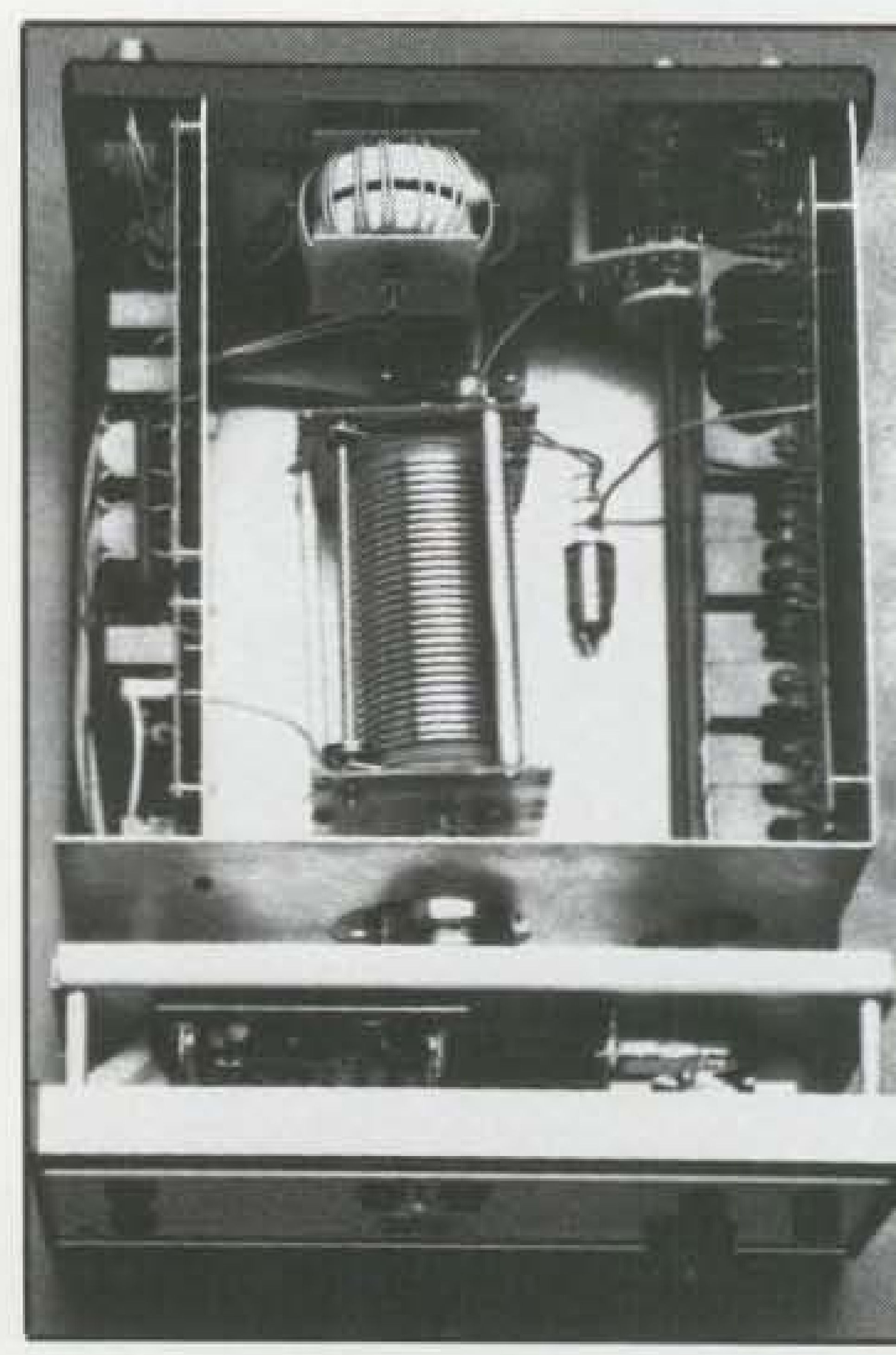
3. At the risk of sounding stupid, I am not sure I agree 100% with this statement. *But,* in my tests I ran 1500 watts output and experienced no problems even though some of my RF voltages were very high.

4. Again, I disagree. What is "best match"?

5. Again, the different settings may or may not be an advantage.

6. I would prefer the writer said "may help" so as not to mislead the beginning-type amateur who has TVI. Do not depend on an antenna tuner to help in cleaning up TVI or RFI.

7. I cannot help but interject that an antenna tuner, from my own countless tests over the years, offers no real help for TVI. *It is possible,* for *any* type of tuner to have stray resonance in the VHF and UHF range that could accent a harmonic. But the only answer for TVI harmonic reduction is simply good shielding and a low-pass filter. CQ



This shows the upper interior of the tuner. The roller inductor is at the center, and the balun for balanced lines is directly behind the roller.